
TEMPLATE
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Device-Independent Graphics Software Comes of Age

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The computer graphics industry is coming of age and this is causing a tremendous surge of interest among potential users who have not previously been professional graphics programmers. To meet the application programming needs of these new users, Megatek has developed a high level general purpose graphics software support system called Template™.

Template was designed to provide both computer and device independence in a graphics application development package, with support for dynamic and static applications in both two- and three- dimensional environments. Its features include line drawing and text generation in both 2D and 3D using high level FORTRAN functions, user-definable viewing environments, structured archiving of graphics objects, general axis generation, color definition and selection, display of 21 character fonts, and a virtual surface capability.

Usable on any 24-bit or larger computer, Template supports virtually any commercially available graphics terminal device—from vector refresh, storage tube and color raster displays to flat-bed or drum pen plotters, COM recorders, alphanumeric line printers and interactive alphanumeric CRT terminals. Template is a comprehensive and modular collection of ANSI compatible FORTRAN subroutines which incorporates the CORE system concepts developed by the Graphics Standards Planning Committee of ACM SIGGRAPH and being used by the X3H3 ANSI Committee on Graphics Standards.

Advances in Computer Graphics Technology

The evolution of computer graphics technology is following a pattern similar to that followed by computer technology generally. Early developments were in the area of hardware innovation. First came the development of batch-processing oriented plotting devices. These were slow, and did not allow interactive input from the operator. Then in the 1960's, the advent of the storage tube display made computer graphics displays available to a broad range of users. The displays were still slow, by today's refresh oriented standards, and they were essentially non-interactive, but speeds were increased significantly over pen plotters and other mechanical plotting devices.

But in scientific and engineering applications, the real advances were yet to come. For example, the most common graphics display used in CAD/CAM systems was the storage tube, primarily because of its low cost. But a tradeoff had to be made for that low cost, because storage tube terminals did not offer multiple colors, were slow in drawing screen images, and offered little dynamic interaction between operator and terminal for on-line design and analysis tasks. Most importantly, the storage tube did not allow "selective erase." The nature of the storage tube re-

formats are supported: integer, real numbers, X-Y coordinates, X-Y-Z coordinates, and text strings. In each case, Template will perform all formatting necessary to display the desired text. For the first four types, the numbers provided are converted to character strings. In the last type, the characters in the provided string are displayed until a user-assignable text terminator character is encountered.

All textural output may be left, right, or center justified both longitudinally and transversely on the justification position. Template produces all output on the current X-Y plane indicated by the Z value. By suitable user coordinate system specifications, output may be produced anywhere in the user's virtual space.

Three types of characters can be produced. Hardware characters are generated by the device's hardware character generator, if one exists. Simulated hardware characters act exactly as hardware characters except they are produced by vector strokes. Both types are positioned to the justification position but will be produced on the display surface plane. Software characters are produced by drawing vectors in the current user coordinate system on the X-Y plane designated by the Z-component of the justification position.

Options are available for specifying individual character orientation, character italicization, character size and spacing, and character string angle from the X-axis. Support for these options in hardware character generators can be utilized but, with the exception of character size, is not simulated. Computer-independent upper/lower case shifting is provided for computer systems which do not have lower case characters. Subscripting and superscripting are available including in-line shifting for text strings. There are also text processing routines to reposition the current position to its previous value and to use the current position as the justification position.

Graphics Structures

A feature often desired by the users of graphics systems is the ability to collect groups of graphics commands into an entity which can later on, or in subsequent runs, be invoked with changes in position, scaling, rotation and mode setting. Moreover, such entities should be archivable in libraries. The Template Graphics Structure facility provides this capability. Structures are basic commands which have been saved as elements containing a command identification and the original input arguments. When the structure is invoked, these commands are re-executed in the current mode environment. The invocation contains a coordinate system definition to position the structure in the current picture space.

While being defined or invoked the structures are maintained in a random work file. If the user desires to save a structure library, a utility routine is available to reformat the structure as card images, which can be reloaded into the work file during subsequent runs. Utilities are also available to delete or rename structures and to merge structure libraries. Since the files are card images, they are computer-system independent and are a means of transmitting graphical images between Template installations.

Picture Organization

The concept of logically dividing the displayable output into segments can facilitate the implementation of some applications and is mandatory for using the selective erasure capability of refresh display devices. The Template segmentation facility allows users to divide the displayable output into named and numbered segments. While segmentation is a feature primarily provided to support selective erase and picking on refresh displays, it is also useful for producing backgrounds for movies or slides.

Associated with each segment are segment attributes which control visibility, highlighting and pick detectability. Each of these may be turned on or off individually for each segment as long as the segment exists. Segments may also have a type which indicates the kind of image transformations which may be applied at the display device, assuming the device in use has local transformation capability. Automatic double buffering is incorporated within the segmentation facility to allow existing segments to be displayed while they are being redefined. When a segment is no longer needed, it may be deleted.

Interaction Routines

One of the most significant difficulties associated with designing a device-independent computer graphics support system involves the handling of interactive graphics peripherals. There exists a wide variety of such devices, including data tablets and digitizers, joysticks, light pens and valuator devices. Many graphics applications make use of operator interaction through such devices in an essential way. In fact, the largest uses of computer graphics in the future will be in those applications involving interactive graphics input during program execution. As a result, any software support system which does not support such devices will not satisfy the needs of most users.

The problem is that different graphics display systems provide different types of interactive graphics peripherals, and some provide none at all. So how can these devices be supported in a device-independent way—in a way which doesn't require reprogramming to support different devices?

Template solves this problem by supporting a large variety of *logical* input devices, including pick, locator, keyboard, digitizer, valuator, and button. These logical devices

"A central line drawing routine can process 40 different line options. Variations within some options can increase the different styles of lines almost indefinitely."

are then associated at program load time with the most appropriate available physical input devices. So input from a locator might come from a joystick if that physical device is available. But if at another time a tablet is available, it can be used as the locator device, and no reprogramming is required. This means the programmer need not concern himself with which devices are actually available, only with the logical functions that are to be performed.

Template's interaction routines support synchronous communication with the terminal operator. Input requests are initiated by calling one of several input functions which prompt the user for input, enable the device, wait for the input to arrive, transform the input to user form, and return it to the calling program. Input requests from the calling program selectively prompt the operator, echo input, transform the input as required, and then return it to the calling program. Segment picking and selection from a Template generated menu provides for additional program control.

Axis Generators and Plotting

A family of higher level functions has been provided in Template to facilitate the creation of axis systems and to use these axis systems to create plots, bar charts, grouped bar charts, histograms, pie charts, scatter diagrams, and time series plots. Each of these uses a central axis system generation facility which produces general 2D and 3D axes in 3-space or creates a view-adjusted 2D axis system where the viewing environment is altered so that the desired axis pair will appear on the projection plane. Label options include the independent selection of numeric labels for the tics on each axis and alphanumeric titles along each axis. Position and format of the labels may be controlled as well as their orientation with respect to the axes.

The axis generation facility is used to automatically plot arrays of data and includes the ability to hold constant, or automatically increment, the values for any coordinate component if individual values for each point are not provided. If several curves are to be produced, any set of points may be automatically repeated if desired. Curve fitting and data averaging utility routines are provided which allow linear, least squares, spline and time series fitting, and many average adjustments.

"...the graphics programmer end user can focus on a small and powerful set of logical graphic utilities and let Template handle mapping these to the available physical devices."

Other Features

One of the most significant features of Template is the virtual display surface facility. Frequently, pictures which are ultimately destined for a specific medium (e.g., 35 mm color slides) are designed on a more interactive display device. Template provides a mnemonic format specification for the production medium. When a format is selected, the display surface of the currently selected display device is configured to produce this format. If it cannot produce the format directly, a subsection of the physical display surface is used to simulate the requested media by providing a formatted display surface occupying the largest rectangle which provides the correct aspect ratio. The display surface dimensions are also set so that the actual dimensions of the requested media are supported. Examples of formats provided are 35mm color slides, 16mm movies, A through E size engineering drawings, and 8½ by 11 inch pages. It is also possible to specify the exact dimensions of the formatted display surface. The flexibility provided by this feature can increase productivity of quality slide-production and related applications significantly.

Another feature is support for user-definable color look-up tables. The normal color selection techniques provide an index for the color table. For some devices the color table consists of fixed color specification (in the case of monochrome systems, the color table contains only one entry). Template allows user specification of color table entries for those display devices which support loadable color tables, such as raster CRT systems and COM recorders.

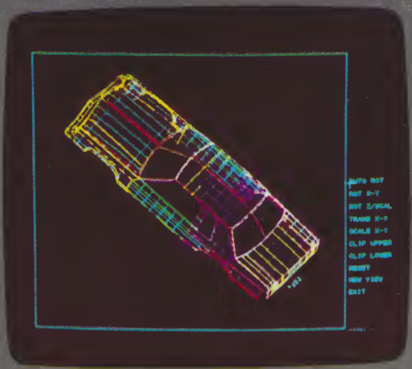
Finally, Template supports a pseudo-display device facility. It produces output on the currently selected display device. The user chooses this device at the time he loads his program. The pseudo-display device is a file which may be substituted for actual display devices at this time. Output produced by Template is stored in a device-independent fashion on the file. This output may then be reproduced on a real display device in a separate program to read the pseudo-device file and copy it to the now currently selected device. This allows display data to be easily moved from computer to computer and from display device to display device without forcing re-execution of the program which produced the data.

Conclusion

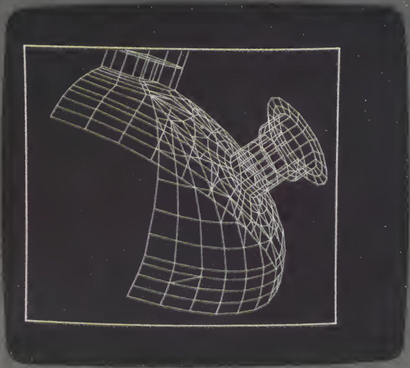
It has not been possible here to detail all the capabilities of Template. However, enough has been provided to indicate the broad range of features provided. These features provide the graphics programmer and user with the tools necessary to solve virtually any application problem, whether it be plots of data, contouring, 2D and 3D modeling, or any other need. Providing these tools in a computer and device-independent way, means software development and maintenance costs are reduced even further. Rather than concern himself with an unending series of graphics display, plotting and input devices, each with its own distinct software protocol, the graphics programmer end user can focus on a small and powerful set of logical graphic utilities and let Template handle mapping these to the available physical devices.

It is only through software tools such as Template that the engineering and scientific uses of computer graphics can fulfill their ultimate promise. ■

Freedom of Expression.



Only Megatek gives you all three, the excitement of dynamic raster color . . .



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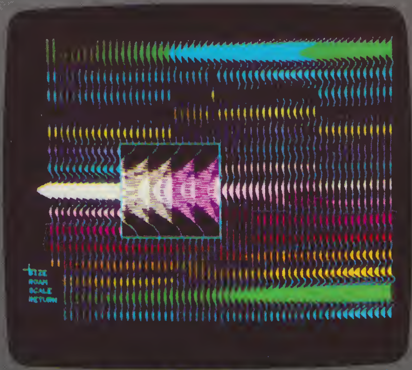
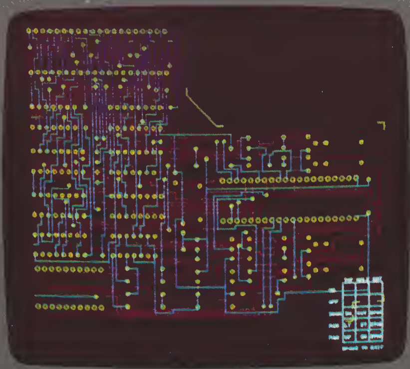
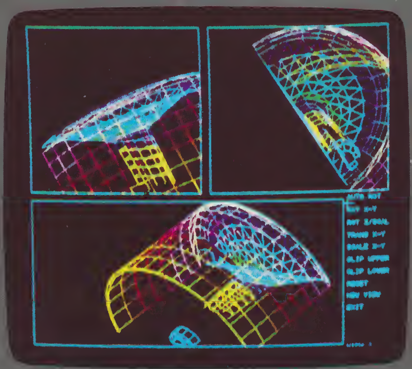
. . . and user-oriented software to make it easy to implement your application.



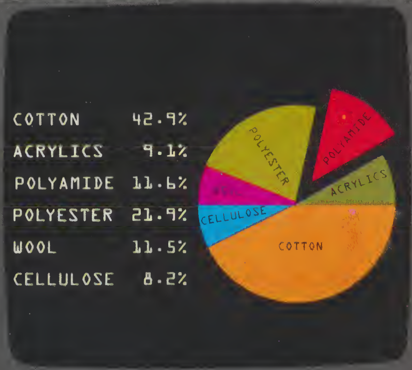
Powerful, real-time dynamics enable you to scan the display then zoom in for added detail.



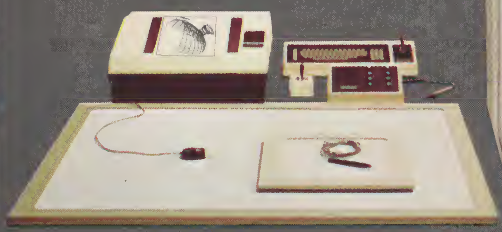
A large virtual display gives you the full picture, with the added information of up to 16 colors at a time.



Rotations mean you can view models from any angle and segment the display into multi-viewports.



It all adds up to the capabilities you need to put your ideas into pictures.



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CRTs Simulate Mechanical Motion of Vehicles

Moline, IL—Deere & Company have added a dynamic animation capability to the computer graphics system used at the Technical Center here for mathematical analysis and simulation studies of agricultural and other equipment.

The addition of a vector refresh graphic system permits them to study the dynamic behavior of such equipment in a direct manner rather than via filmed animation of storage tube displays. One terminal being used is a Whizzard 7000 vector refresh terminal interfaced to a Prime 400 timesharing system.

Deere engineers have simulated the dynamic behavior of farm implements and other heavy equipment for several years. Each system is modeled as rigid body elements interconnected with discrete elastic and damping elements. Computer simulations of the dynamic behavior are then processed by forcing the model with specific external forces or displacements. The two major programs now used at Deere for simulation of large-scale systems are DRAM (Dynamic Response of Articulated Machinery) and ADAMS (Automated Dynamic Analysis of Mechanical Systems).

In the early stages of the simulation development, the computer results were obtained from printouts of forces, displacements, velocites, and accelerations. Although these massive collections of numbers are necessary, when taken by themselves the engineer often cannot grasp the overall behavior predicted by the simulation. What the engineer needed was realistic graphics display that showed the predicted motion.

About six years ago the Technical Center staff began development of a software package to draw three-dimensional representations of objects to display the results of the computer simulations on storage tube graphics terminals. The displays were composed of straight line segments, curves, ruled surfaces, and irregularly bounded planes which can contain holes—much like engineering drawings but without the nuts-and-bolts detail. Drawings could be viewed from any direction with hidden lines automatically removed for clarity.

Since storage tube displays must be redrawn every time an element is changed in the picture, animation is difficult. The approach used initially at Deere involved filming the storage displays to produce the animation.

A motion picture camera was set up in front of the display and wired for control by the computer. The system would draw one frame of the simulation on the video screen and trigger the camera to take one or more frames. Then it would advance the film, draw the next picture on the screen, and expose it. At best, the filming of a tractor dynamics sequence might take anywhere from three to four hours to complete, not counting processing and production time.

The additon of a vector refresh terminal now reduces the time between the simulation run and an animated display dramatically. A vector refresh terminal has a dynamic line drawing capability to generate animated sequences the engineers can watch "live." The vector refresh graphics display can be redrawn continuously from new data at the specific time intervals of the simulation to provide a realistic animation of the design.

Using the Deere & Company software, drawings can be rotated, scaled, clipped, or translated so the engineer can view the same simulation results from all directions needed to see the interaction between various components. In other words, one set of simulation results can be displayed any number of times from different directions.

Although the Technical Center staff has been providing sophisticated capabilities to Deere research and design engineers for several years, the additon of dynamic interactive graphics has extended the usefulness of the simulations and considerably reduced the man-hour requirements to produce them.

Close-up of screen shows tractor simulation.